Space Weather Technical Forecast

Issued on Saturday, 25 December 2021 at 12:36 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Slight chance of G1/Minor Storms on 27 December. Chance of M-class flares (R1/R2 Radio Blackout), with slight chance of X-class (R3 Radio Blackout).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been low over the past 24 hours, with numerous C-class flares observed. The most significant flare activity was mainly concentrated in the southwest quadrant from 2907 (Ehi/Beta) and 2908, which has now faded to plage. 2917 (Bxo/beta) has weakened significantly. 2918 (Eai/Beta) is still developing and has the potential to produce significant flares. 2916 (Ehi/Beta) has also grown. All the other regions are either benign, stable or declining in complexity.

A CME was observed leaving the Sun close to the region of 2907 or 2908 at 24/1130UTC, modelling suggests that this is not Earth-directed.

Solar Wind / Geomagnetic Activity: Solar wind speeds as observed by DSCOVR at L1 have been slightly elevated under the influence of coronal hole 35. Density has been around average with little change. Interplanetary magnetic field strength was weak, with the north-south component also varying weakly. Phi angle has been predominantly negative (towards the Sun). Geomagnetic activity was Quiet (Kp 1-2).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at background levels. The high energy electron flux (greater than 2 MeV) was high until 24/2020UTC, reaching a peak of 2.02e3 pfu at 24/1715UTC. The associated 24-hour integrated fluence started above the Active threshold, but has declined through the 24 hour period. At 25/0001UTC it was 9.21e7 integrated pfu.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Low solar activity is forecast throughout the period, with a chance of M-class flares and a slight chance of X-class flares. This is due to several active regions with significant flare potential.

Solar Wind / Geomagnetic Activity: There are two potentially Earth-directed CMEs forecast, with the 20 December CME now removed from the forecast. These two CMEs left the Sun on 21 and 22 December respectively and could glance the Earth on 26 or 27 December. A CME which left the Sun on 24 December is not forecast to affect Earth. The high speed stream from coronal hole 37 is forecast to connect with Earth on 27 December, with expected speeds of around 500km/s. Mainly Quiet geomagnetic activity is forecast through days 1 and 2, with a chance of Active and a slight chance of G1/Minor Storms on day 3 due to the coronal hole effects.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels and below the S1 level, although there is a slight chance for some increased flux from any significant flare activity. High energy electron flux (greater than 2MeV) levels are forecast to fall to increasingly moderate levels through the next two days, with a more significant fall to background on day 3 following the forecast heightened geomagnetic activity. Electron fluence is expected to follow a declining trend and remain below the Active (1e8 integrated pfu) threshold.

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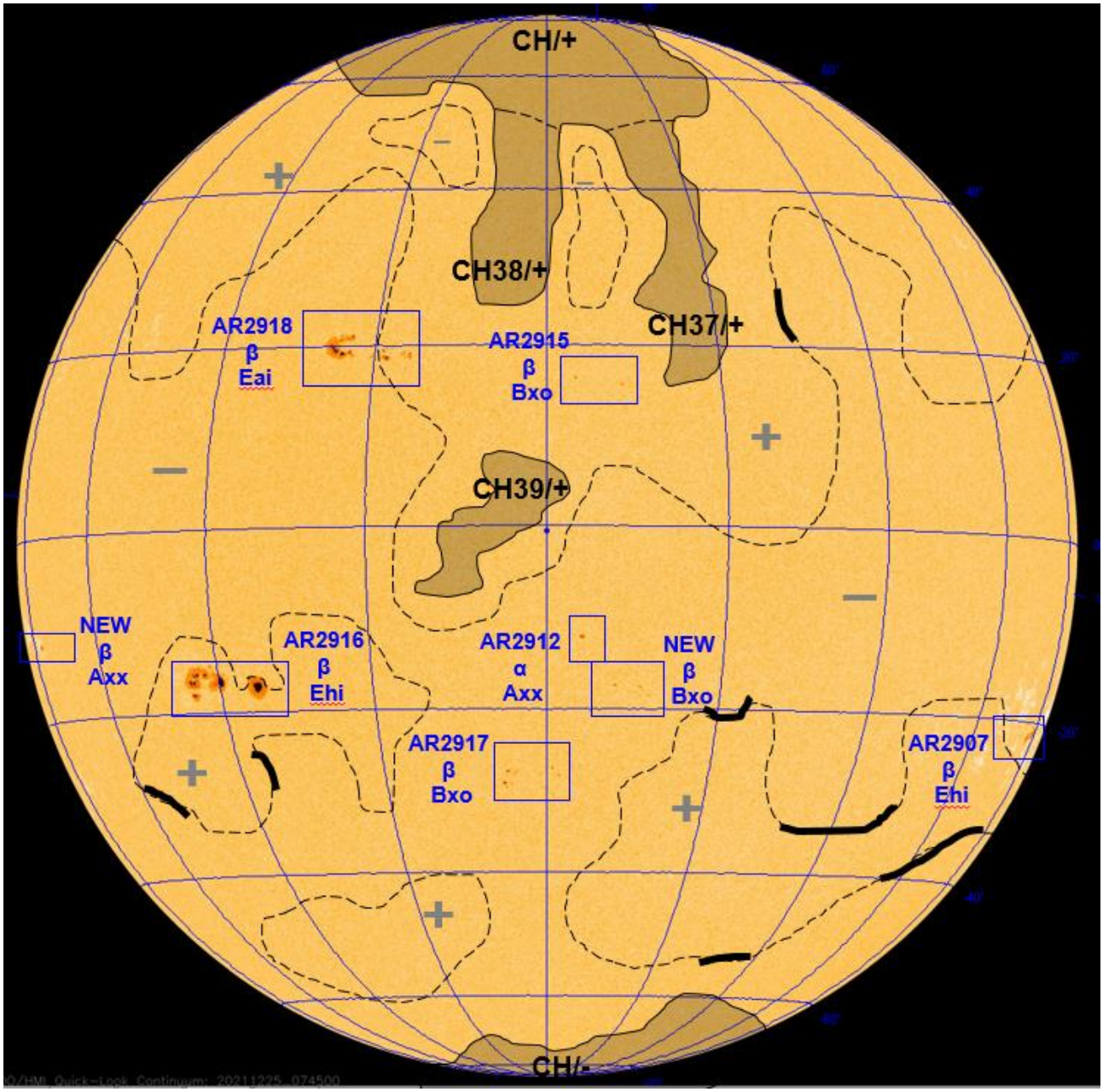
Figure 1. Solar Analysis Valid 25/0800UTC.



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Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Three CMEs are currently modelled by Enlil. The first two, which left the Sun on 21 and 22 December respectively, may glance the Earth on 26 or 27 December. However, as both were relatively narrow features, there is low confidence in this aspect of the forecast and they could miss entirely. The remaining CME left the Sun from the southwest quadrant early on 24 December and analysis suggests that this will miss the Earth.

Coronal hole 37 is forecast to connect with the Earth on 27 December. This is a recurrent feature which produced speeds of around 500km/s on the previous rotation. Similar speeds are assumed on this rotation, as the feature has not yet been detected at STEREO A. If the speeds from the hole are slightly higher, then an earlier arrival is possible.

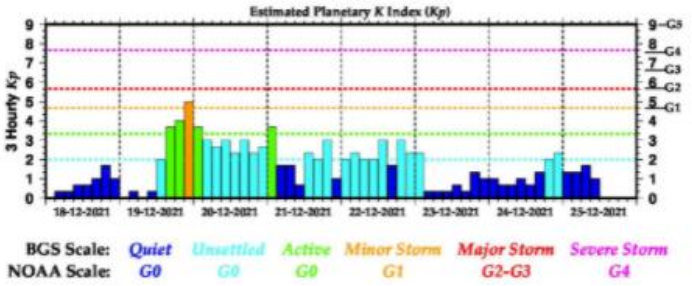
Geomagnetic activity is expected to be mainly Quiet on day 1 (25 December). Mainly Quiet conditions are then expected through day 2 (26th), with a chance of Active and a slight chance of G1/Minor Storm intervals later in the day and on day 3 (27th), due to the anticipated connection with the high speed stream from coronal hole 37. A smaller risk of G1/Minor Storm conditions are maintained into day 4.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	10	20	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
22/0726Z	Partial Halo	2908	SW limb	475km/s	27/1300Z	Limited shock
22/1735Z	Partial Halo	2908	SW limb	310km/s	27/1300Z	Limited shock

Figure 2: BGS Kp index has been mainly Quiet



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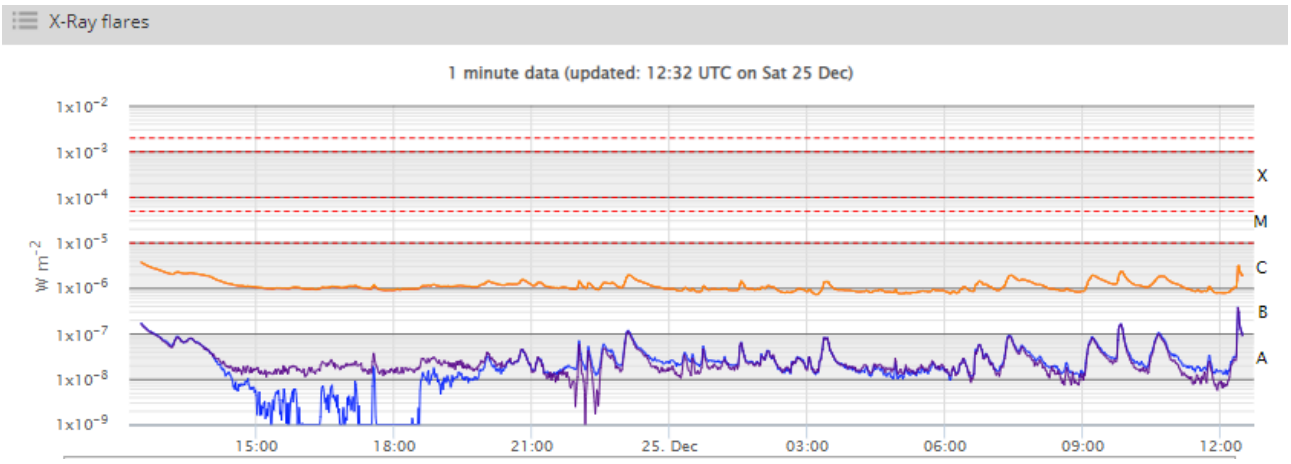
Radio Blackouts - X-Ray Flares:
There are 8 sunspot regions on the visible disc. Three of these contribute the most to the overall flare risk. 2907 is now close to the southwestern limb and will rotate across the horizon in the next 36 hours. This is classified as Ehi/Beta and continues to flare, producing a CME on the 24th. 2916 in the southeast quadrant is also classified as Ehi/Beta and presents an elevated flare risk for the next four days and is seeing development in the trailer spots. 2918 has developed into an Eai/ Beta classification.

Two new regions have emerged over the last 24 hours. One in the southeast the other in the southwest. Both a weak and stable. The remaining regions are either stable, benign or declining regions.
Overall, given that a number of the developing regions are in the eastern hemisphere, a chance of M-class flares is maintained through the next four days, with a slight chance of X-class flares.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	40	30	30
Very Active	R3 to R5 X Class	No	15	15	5	5

Figure 3: GOES16 X-Ray flares shows frequent minor C-class flaring.



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Solar Radiation Storms - (High Energy Protons):
The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently at background levels and expected to persist at these levels. 2907 is considered to be the most likely region as a source for any proton storms and despite rotating across the horizon on day 2, any storms could be carried to Earth in the Parker spiral.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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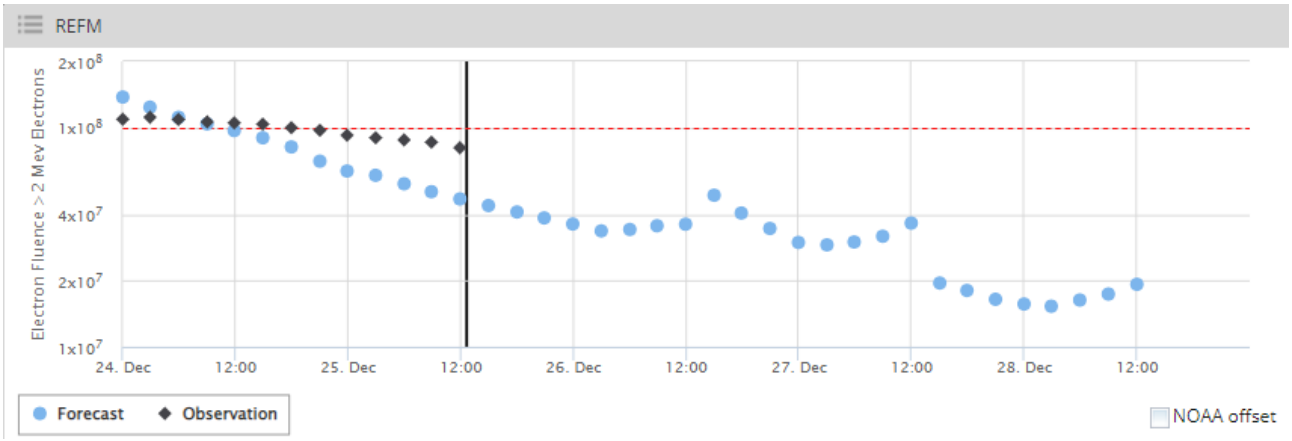
High Energy Electrons Event (≥ 2MeV):

The high energy electron flux has been at mainly moderate to high levels due to the input from the high speed stream of coronal hole 35. As this high speed stream declines, the diurnal maximum is expected to decline on days 1 and 2 (25th and 26th), with high levels increasingly unlikely. A more sustained drop in electron flux is expected on day 3 (27th) due to the connection with the high speed stream from coronal hole 37. The increase in geomagnetic activity will result in a redistribution of the electrons within the belts, with the strength of the high speed stream likely to distort the belts out of GEO. A minor recovery in counts may develop through day 4 (28th).

Electron fluence values are following a declining trend, which is reflected in the MOSWOC REFM model. This pattern is accepted through the forecast period, with a decreasing chance of exceeding the Active threshold.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	Yes	50	20	10	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Figure 5: MOSWOC REF Model is forecasting a steady decline in fluence values.



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